

I. PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-220990

(43)Date of publication of application : 18.08.1995

(51)Int.Cl.

H01L 21/027

G03F 7/20

(21)Application number : 06-008136

(71)Applicant : HITACHI LTD

(22)Date of filing : 28.01.1994

(72)Inventor : FUKUDA HIROSHI
TANAKA TOSHIHIKO

(54) PATTERN FORMING METHOD AND EXPOSURE APPARATUS THEREFOR

(57)Abstract:

PURPOSE: To improve resolution by forming a projection optical system of an optical system having a reflection type lens, and fully filling entirety or part of an optical path of the projection system included between a surface of a board and the projection system with medium having 1 or more of specific refractive index to the air in the wavelength of a light.

CONSTITUTION: A beam 12 generated from a KrF excimer laser 11 is emitted to a mask 3 via a beam shaping optical system 13 and an illumination optical system 2. A light passing through the mask 3 is exposed on a board 5 via a reflection type contraction projection lens 7. The lens 7 is a Schwarzschild type optical system having a numerical aperture of 0.3 to focus the mask 3 on the board 5. The entire system from the irradiating side of the illumination system to the board via the mask is installed in a liquid vessel 14, and water is fully filled in the vessel to fill the water in the optical path. Then, a pattern is transferred to a positive resist film coating the

Si board by using a projection exposure apparatus to form a $0.35\mu\text{mL/S}$ pattern.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]

[Claim 1] In the approach of forming a pattern on the above-mentioned substrate by irradiating at a mask the light which emitted the light source through an illumination-light study system, and carrying out image formation of the pattern on the above-mentioned mask to up to a substrate according to a projection optical system The pattern formation approach characterized by filling with a medium with the bigger rate of specific refraction to the air in the wavelength of the above-mentioned light than 1 the whole optical path or a part of the above-mentioned projection optical system which constitutes the above-mentioned projection optical system according to the optical system containing a reflective mold lens, and includes between the above-mentioned substrate and the above-mentioned projection optical systems at least.

[Claim 2] It is the pattern formation approach that the above-mentioned medium is a liquid in claim 1.

[Claim 3] It is the pattern formation approach that the wavelength of the above-mentioned light is 150-250nm in claim 2.

[Claim 4] In the aligner used in case a pattern is formed on the above-mentioned substrate by irradiating at a mask the light which emitted the light source through an illumination-light study system, and carrying out image formation of the pattern on the above-mentioned mask to up to a substrate according to a projection optical system The projection aligner characterized by filling with a medium with the bigger rate of specific refraction to the air in the wavelength of the above-mentioned light than 1 the whole optical path or a part of the above-mentioned projection optical system which constitutes the above-mentioned projection optical system according to the optical system containing a reflective mold lens, and includes between the above-mentioned substrate and the above-mentioned projection optical systems.

[Claim 5] The projection aligner which forms a transparent septum between the above-mentioned projection optical system and said substrate, and divides the above-mentioned medium into an optical-system and substrate side in claim 4.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to the pattern formation approach for forming the detailed pattern of various solid-state components, and the projection aligner used for this.

[0002]

[Description of the Prior Art] In order to improve the degree of integration and working speeds of a solid-state component, such as LSI, detailed-ization of a circuit pattern is progressing. The reduced-projection-exposure method excellent in mass production nature and definition ability is widely used for such pattern formation now.

[0003] The optical system of a reduced-projection-exposure method is typically shown in drawing 2 (b). The light which emitted the effective light source 1 on a secondary surface of light source is irradiated by the mask 3 through the illumination-light study system 2, and image formation of the light diffracted with the pattern on a mask 3 is carried out on a substrate 5 with the cutback projection lens 4. What a cutback projection lens usually becomes from the combination of a refraction mold lens is used. Since the resolution limit of this approach is proportional to exposure wavelength and it is in inverse proportion to the numerical aperture (NA) of a projection lens, improvement in the resolution limit has been performed by a raise in NA, and short wavelength-ization. Conventionally, after 64-megabit DRAM, the circuit dimension became smaller than the wavelength of light, and exposure light has reached the physical limitation, although g line (wavelength of 436nm) of a high-pressure mercury lamp and i line (wavelength of 365nm) have been used.

[0004] as the approach of on the other hand increasing effectual NA of the optical system of a microscope etc. -- immersion (oil immersion) -- law is known. By being filled up with the liquid (an oil usually being used) which has the bigger refractive index n than air between the head of a lens, and a sample, this approach sets wavelength of light to $1/n$ effectually, and raises resolution. The application to the optical lithography of this approach is discussed by for example, the collection of the 53rd Japan Society of Applied Physics scientific lecture meeting lecture drafts, the 2nd separate volume, and the 472nd page (1992).

[0005] On the other hand, the approach using reflective mold projection optical systems, such as a step and a scanning method, as another gestalt of the projection aligner for optical lithographies is examined. It is not based on wavelength but this optical system is a maximum of 0.7. To NA with big extent, implementation is made possible and it is dramatically promising as a future aligner. In this method, although a refraction mold optical element is used for a part, since chromatic-aberration amendment is possible, it exposes in the comparatively large wavelength field of 245-253nm of a xenon mercury lamp. For this reason, stabilization of wavelength is not needed by any means with narrow-band-ization of a precise laser wavelength spectrum like a excimer laser stepper using the conventional full refraction mold optical system, and multiplex cross protection and the standing wave effectiveness can be reduced. Moreover, it is the practical big features that exposure area is also large.

[0006] The optical system of a step and a scanning method is discussed by the 14th page from the 12th page (TECHNICAL INFORMATION INSTITUTE, Tokyo, 1991) of a resist ingredient process technique.

[0007]

[Problem(s) to be Solved by the Invention] By the way, refraction mold objective lenses, such as a microscope used with the above-mentioned conventional immersion method, are designed by dedication on the assumption that it is filled up with the liquid of a predetermined refractive index between a lens head and a sample. The same of this situation is said of the case of the lens for projection exposure, and it is necessary to design the projection lens corresponding to immersion specially as an exclusive lens with a design which is completely conventionally different from a lens. Here, suppose that the liquid restoration field 6 (drawing 2 (b) shadow area) between the head of conventional-type dioptric lenses other than for immersion and a substrate (or sample) was temporarily filled up with the liquid of a refractive index n . In this case, although wavelength is effectually set to $1/n$, in order that the angle of refraction in a lens head may decrease according to a Snell's law, the optical path of a beam of light changes like the broken line of drawing 2 (b), and effectual NA decreases. For this reason, resolution does not necessarily improve. And there was a problem that it was very difficult to reconcile with big NA peculiar to an immersion lens a large exposure area demanded in the lens for steppers.

[0008] It is desirable to shorten exposure wavelength as much as possible on the other hand, in order to improve the resolution of optical lithography further. However, both the exposing method by conventional-type dioptric system and the reflective mold projection exposing method had the problem that ArF excimer laser (wavelength of 193nm) will become the limitation of practical short-wavelength-izing from the limitation of the permeability of an optical material.

[0009] It is to offer the pattern formation approach which can be improved to a limit in the resolution of the projection exposing method, the object of this invention acquiring the improvement effectiveness in resolution equivalent to having short-wavelength-ized effectually simple, and securing a large exposure field, without changing greatly the configuration and optical system of an aligner of a conventional type.

[0010]

[Means for Solving the Problem] In the approach of forming a pattern on the above-mentioned substrate by this invention's irradiating at a mask the light which emitted the light source through an illumination-light study system, and carrying out image formation of the pattern on the above-mentioned mask to up to a substrate according to a projection optical system, in order to attain the above-mentioned object The optical system containing a reflective mold lens constitutes the above-mentioned projection optical system, and the whole optical path or a part of the above-mentioned projection optical system which includes between the above-mentioned substrate and the above-mentioned projection optical systems at least is filled with a medium with the bigger rate of specific refraction to the air in the wavelength of the above-mentioned light than 1.

[0011]

[Function] It considers changing the refractive index of the medium which fulfills the whole optical path of the catoptric system shown in drawing 2 (a). Drawing 2 (a) transposes the refraction mold cutback projection lens 4 in drawing 2 (b) to the reflective mold cutback projection lens 7. In drawing 2 (a), the continuous line and the dotted line showed respectively the optical path of a beam of light when the refractive index of a medium is small, and the optical path of the beam of light in the case of being large. The optical path in catoptric system is decided only by the shape of surface type of a reflective lens according to a reflective principle, and is not based on the refractive index of a medium. Therefore, even if it changes the refractive index of a medium, the geometrical optics-property of optical system, such as numerical aperture, does not change at all. On the other hand, if the matter of the rate n of specific

refraction to a vacuum is used as a medium, wavelength will be effectually set to $1/n$.

Consequently, effectiveness equal to only wavelength having become short substantially is acquired. in addition -- although perfect catoptric system was assumed and explained by drawing 2 (a) since it was easy -- partial -- dioptric system -- business -- a potato is good.

[0012] Moreover, a medium is 1.2, in order that it may be desirable for the refractive index to exposure wavelength to be large as much as possible and it may acquire sufficient resolution effectiveness. It is desirable that it is above. Moreover, it is substantially transparent to exposure wavelength, and it is desirable not to have an adverse effect on an optical element and a resist. Specifically, organic solvents, such as water or alcohol, and a straight chain hydrocarbon, silicone resin, the liquid that dissolved the inorganic compound or the organic compound in these further, the various liquids currently conventionally used in an immersion microscope, the immersion method of determination of index of refraction, etc. can be used.

[0013] In addition, since there is a possibility of having an adverse effect on the image formation property of optical system when a refractive index changes with fluctuation of the temperature of a medium, a consistency, etc. in optical system, as for these temperature etc., controlling carefully is desirable. Since a substrate is especially scanned to optical system by scan optical system, it is desirable to take care so that an image formation property may not change with the flow of a medium.

[0014]

[Example]

(Example 1) The reflective mold projection aligner by one example of this invention is shown in drawing 1. The laser beam 12 generated from the KrF excimer laser 11 is irradiated at a mask 3 through the beam plastic surgery optical system 13 and the illumination-light study system 2. The light which passed the mask exposes a substrate 5 through the reflective mold cutback projection lens 7. Reflective mold reducing glass is a numerical aperture 0.3. By the Schwartz SHURUDO mold optical system, image formation of the mask 3 is carried out on a substrate 5. However, the optical system in drawing is typical strictly, and is not what showed the configuration of actual optical system faithfully. Here, the whole optical system from the injection side of an illumination-light study system to a substrate through a mask was installed in the interior of a liquid container 14, and into the liquid container, water was filled and it was filled up with the optical path with water.

[0015] Next, it is 0.35micromL/S as a result of imprinting the pattern of various dimensions using a projection aligner on the positive-resist film (PMMA, 1 micrometer of thickness) applied on Si substrate. The pattern has been formed. For the comparison, when water was removed from optical system and having been exposed in air, the resolution limit retreated to 0.5 micrometers.

[0016] In addition, the method of the wavelength of an aligner, the class of light source, and a projection lens and a numerical aperture, the class of medium, the resist process to be used, a mask pattern dimension, etc. are not limited to what was shown in this example. For example, a high-pressure mercury lamp and a xenon mercury lamp may be used instead of excimer laser. Moreover, into a liquid solution, it may replace with water and a perfluoroalkyl polyether etc. may be used. While this liquid was transparent on exposure wavelength, the sensitization property of a resist was not affected at all. Moreover, it may replace with PMMA also as a resist and a suitable novolak system positive resist, a chemistry multiplier system resist, etc. may be used.

[0017] (Example 2) The reflective mold projection aligner by the second example of this invention is shown in drawing 3. The laser beam generated from ArF excimer laser (not shown)

is irradiated at a mask 3 through beam plastic surgery optical system and an illumination-light study system (not shown). The light which passed the mask exposes a substrate 5 through the scanning catoptric system 21. Scanning catoptric system is numerical aperture 0.7. It is a step and scanning mold optical system, and image formation of the mask 3 is carried out on a substrate 5. However, the optical system in drawing is typical strictly, and is not what showed the configuration of actual optical system faithfully. Here, the field 22 shown with the slash in drawing within the optical path of a projection optical system was filled up with water.

[0018] Next, it is 0.11micromL/S as a result of imprinting the pattern of various dimensions using a projection aligner on the positive-resist film (PMMA, 1 micrometer of thickness) applied on Si substrate. The pattern has been formed. The resolution limit is 0.15 micrometers, when water was removed from optical system and it exposed in air for the comparison. It retreated and the effectiveness of this invention was checked.

[0019] (Example 3) In the projection aligner of an example 2, as shown in drawing 4 , the parallel plate 31 of a quartz divided the optical-system and substrate side. In order that the flow of the liquid medium produced when a substrate is scanned to optical system or step feed is carried out by this might not attain to an optical-system side, the effect of fluctuation etc. of a refractive index was suppressed and the dimensional accuracy of a pattern improved. In addition, to the spherical aberration generated by quartz aperture insertion, it amended beforehand.

[0020] (Example 4) In the projection aligner of an example 2, as shown in drawing 5 , the quartz parallel plates 32 and 33 were formed between optical system and a substrate, and the liquid container was divided into the optical-system side liquid container 34 and the substrate side liquid container 35. Furthermore, it was made to perform the scan or step feed to the optical system of a substrate 5 the whole substrate side liquid container 35. Thereby, since the flow of the liquid near the substrate was also controlled, the effect of fluctuation etc. of a refractive index was suppressed and the dimensional accuracy of a pattern improved further.

[0021] In addition, when applying the configuration by this example to an example 1, the same device also as a mask side can be established.

[0022]

[Effect of the Invention] In case a pattern is imprinted on the above-mentioned substrate by carrying out image formation of the mask pattern to up to a substrate according to a projection optical system according to this invention, while the optical system containing a reflective mold lens constitutes a projection optical system By filling the whole optical path or a part of projection optical system including between a substrate front face and projection optical systems with a medium with the bigger rate of specific refraction to the air in the wavelength of light than 1 Improvement in resolution equivalent to having short-wavelength-ized effectually simple can be aimed at without changing greatly the configuration and optical system of an aligner of a conventional type. Thereby, the resolution limit of optical lithography is improved about 30%, and it is 0.15 micrometers. It becomes possible to form the following patterns.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] This invention relates to the pattern formation approach for forming the detailed pattern of various solid-state components, and the projection aligner used for this.

[Translation done.]

PRIOR ART

[Description of the Prior Art] In order to improve the degree of integration and working speeds of a solid-state component, such as LSI, detailed-ization of a circuit pattern is progressing. The reduced-projection-exposure method excellent in mass production nature and definition ability is widely used for such pattern formation now.

[0003] The optical system of a reduced-projection-exposure method is typically shown in drawing 2 (b). The light which emitted the effective light source 1 on a secondary surface of light source is irradiated by the mask 3 through the illumination-light study system 2, and image formation of the light diffracted with the pattern on a mask 3 is carried out on a substrate 5 with the cutback projection lens 4. What a cutback projection lens usually becomes from the combination of a refraction mold lens is used. Since the resolution limit of this approach is proportional to exposure wavelength and it is in inverse proportion to the numerical aperture (NA) of a projection lens, improvement in the resolution limit has been performed by a raise in NA, and short wavelength-ization. Conventionally, after 64-megabit DRAM, the circuit dimension became smaller than the wavelength of light, and exposure light has reached the physical limitation, although g line (wavelength of 436nm) of a high-pressure mercury lamp and i line (wavelength of 365nm) have been used.

[0004] as the approach of on the other hand increasing effectual NA of the optical system of a microscope etc. -- immersion (oil immersion) -- law is known. By being filled up with the liquid (an oil usually being used) which has the bigger refractive index n than air between the head of a lens, and a sample, this approach sets wavelength of light to $1/n$ effectually, and raises resolution. The application to the optical lithography of this approach is discussed by for example, the collection of the 53rd Japan Society of Applied Physics scientific lecture meeting lecture drafts, the 2nd separate volume, and the 472nd page (1992).

[0005] On the other hand, the approach using reflective mold projection optical systems, such as a step and a scanning method, as another gestalt of the projection aligner for optical lithographies is examined. It is not based on wavelength but this optical system is a maximum of 0.7. To NA with big extent, implementation is made possible and it is dramatically promising as a future aligner. In this method, although a refraction mold optical element is used for a part, since chromatic-aberration amendment is possible, it exposes in the comparatively large wavelength field of 245-253nm of a xenon mercury lamp. For this reason, stabilization of wavelength is not needed by any means with narrow-band-ization of a precise laser wavelength spectrum like a excimer laser stepper using the conventional full refraction mold optical system, and multiplex cross protection and the standing wave effectiveness can be reduced. Moreover, it is the practical big features that exposure area is also large.

[0006] The optical system of a step and a scanning method is discussed by the 14th page from the 12th page (TECHNICAL INFORMATION INSTITUTE, Tokyo, 1991) of a resist ingredient

process technique.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] In case a pattern is imprinted on the above-mentioned substrate by carrying out image formation of the mask pattern to up to a substrate according to a projection optical system according to this invention, while the optical system containing a reflective mold lens constitutes a projection optical system By filling the whole optical path or a part of projection optical system including between a substrate front face and projection optical systems with a medium with the bigger rate of specific refraction to the air in the wavelength of light than 1 Improvement in resolution equivalent to having short-wavelength-ized effectually simple can be aimed at without changing greatly the configuration and optical system of an aligner of a conventional type. Thereby, the resolution limit of optical lithography is improved about 30%, and it is 0.15 micrometers. It becomes possible to form the following patterns.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] By the way, refraction mold objective lenses, such as a microscope used with the above-mentioned conventional immersion method, are designed by dedication on the assumption that it is filled up with the liquid of a predetermined refractive index between a lens head and a sample. The same of this situation is said of the case of the lens for projection exposure, and it is necessary to design the projection lens corresponding to immersion specially as an exclusive lens with a design which is completely conventionally different from a lens. Here, suppose that the liquid restoration field 6 (drawing 2 (b) shadow area) between the head of conventional-type dioptric lenses other than for immersion and a substrate (or sample) was temporarily filled up with the liquid of a refractive index n . In this case, although wavelength is effectually set to $1/n$, in order that the angle of refraction in a lens head may decrease according to a Snell's law, the optical path of a beam of light changes like the broken line of drawing 2 (b), and effectual NA decreases. For this reason, resolution does not necessarily improve. And there was a problem that it was very difficult to reconcile with big NA peculiar to an immersion lens a large exposure area demanded in the lens for steppers.

[0008] It is desirable to shorten exposure wavelength as much as possible on the other hand, in order to improve the resolution of optical lithography further. However, both the exposing method by conventional-type dioptric system and the reflective mold projection exposing method had the problem that ArF excimer laser (wavelength of 193nm) will become the limitation of practical short-wavelength-izing from the limitation of the permeability of an

optical material.

[0009] It is to offer the pattern formation approach which can be improved to a limit in the resolution of the projection exposing method, the object of this invention acquiring the improvement effectiveness in resolution equivalent to having short-wavelength-ized effectually simple, and securing a large exposure field, without changing greatly the configuration and optical system of an aligner of a conventional type.

[Translation done.]

MEANS

[Means for Solving the Problem] In the approach of forming a pattern on the above-mentioned substrate by this invention's irradiating at a mask the light which emitted the light source through an illumination-light study system, and carrying out image formation of the pattern on the above-mentioned mask to up to a substrate according to a projection optical system, in order to attain the above-mentioned object The optical system containing a reflective mold lens constitutes the above-mentioned projection optical system, and the whole optical path or a part of the above-mentioned projection optical system which includes between the above-mentioned substrate and the above-mentioned projection optical systems at least is filled with a medium with the bigger rate of specific refraction to the air in the wavelength of the above-mentioned light than 1.

[Translation done.]

OPERATION

[Function] It considers changing the refractive index of the medium which fulfills the whole optical path of the catoptric system shown in drawing 2 (a). Drawing 2 (a) transposes the refraction mold cutback projection lens 4 in drawing 2 (b) to the reflective mold cutback projection lens 7. In drawing 2 (a), the continuous line and the dotted line showed respectively the optical path of a beam of light when the refractive index of a medium is small, and the optical path of the beam of light in the case of being large. The optical path in catoptric system is decided only by the shape of surface type of a reflective lens according to a reflective principle, and is not based on the refractive index of a medium. Therefore, even if it changes the refractive index of a medium, the geometrical optics-property of optical system, such as numerical aperture, does not change at all. On the other hand, if the matter of the rate n of specific refraction to a vacuum is used as a medium, wavelength will be effectually set to $1/n$. Consequently, effectiveness equal to only wavelength having become short substantially is acquired. in addition -- although perfect catoptric system was assumed and explained by drawing 2 (a) since it was easy -- partial -- dioptric system -- business -- a potato is good.

[0012] Moreover, a medium is 1.2, in order that it may be desirable for the refractive index to

exposure wavelength to be large as much as possible and it may acquire sufficient resolution effectiveness. It is desirable that it is above. Moreover, it is substantially transparent to exposure wavelength, and it is desirable not to have an adverse effect on an optical element and a resist. Specifically, organic solvents, such as water or alcohol, and a straight chain hydrocarbon, silicone resin, the liquid that dissolved the inorganic compound or the organic compound in these further, the various liquids currently conventionally used in an immersion microscope, the immersion method of determination of index of refraction, etc. can be used.

[0013] In addition, since there is a possibility of having an adverse effect on the image formation property of optical system when a refractive index changes with fluctuation of the temperature of a medium, a consistency, etc. in optical system, as for these temperature etc., controlling carefully is desirable. Since a substrate is especially scanned to optical system by scan optical system, it is desirable to take care so that an image formation property may not change with the flow of a medium.

[Translation done.]

EXAMPLE

[Example]

(Example 1) The reflective mold projection aligner by one example of this invention is shown in drawing 1. The laser beam 12 generated from the KrF excimer laser 11 is irradiated at a mask 3 through the beam plastic surgery optical system 13 and the illumination-light study system 2. The light which passed the mask exposes a substrate 5 through the reflective mold cutback projection lens 7. Reflective mold reducing glass is a numerical aperture 0.3. By the Schwartz SHURUDO mold optical system, image formation of the mask 3 is carried out on a substrate 5. However, the optical system in drawing is typical strictly, and is not what showed the configuration of actual optical system faithfully. Here, the whole optical system from the injection side of an illumination-light study system to a substrate through a mask was installed in the interior of a liquid container 14, and into the liquid container, water was filled and it was filled up with the optical path with water.

[0015] Next, it is 0.35micromL/S as a result of imprinting the pattern of various dimensions using a projection aligner on the positive-resist film (PMMA, 1 micrometer of thickness) applied on Si substrate. The pattern has been formed. For the comparison, when water was removed from optical system and having been exposed in air, the resolution limit retreated to 0.5 micrometers.

[0016] In addition, the method of the wavelength of an aligner, the class of light source, and a projection lens and a numerical aperture, the class of medium, the resist process to be used, a mask pattern dimension, etc. are not limited to what was shown in this example. For example, a high-pressure mercury lamp and a xenon mercury lamp may be used instead of excimer laser. Moreover, into a liquid solution, it may replace with water and a perfluoroalkyl polyether etc. may be used. While this liquid was transparent on exposure wavelength, the sensitization property of a resist was not affected at all. Moreover, it may replace with PMMA also as a resist and a suitable novolak system positive resist, a chemistry multiplier system resist, etc. may be used.

[0017] (Example 2) The reflective mold projection aligner by the second example of this invention is shown in drawing 3 . The laser beam generated from ArF excimer laser (not shown) is irradiated at a mask 3 through beam plastic surgery optical system and an illumination-light study system (not shown). The light which passed the mask exposes a substrate 5 through the scanning catoptric system 21. Scanning catoptric system is numerical aperture 0.7. It is a step and scanning mold optical system, and image formation of the mask 3 is carried out on a substrate 5. However, the optical system in drawing is typical strictly, and is not what showed the configuration of actual optical system faithfully. Here, the field 22 shown with the slash in drawing within the optical path of a projection optical system was filled up with water.

[0018] Next, it is 0.11micromL/S as a result of imprinting the pattern of various dimensions using a projection aligner on the positive-resist film (PMMA, 1 micrometer of thickness) applied on Si substrate. The pattern has been formed. The resolution limit is 0.15 micrometers, when water was removed from optical system and it exposed in air for the comparison. It retreated and the effectiveness of this invention was checked.

[0019] (Example 3) In the projection aligner of an example 2, as shown in drawing 4 , the parallel plate 31 of a quartz divided the optical-system and substrate side. In order that the flow of the liquid medium produced when a substrate is scanned to optical system or step feed is carried out by this might not attain to an optical-system side, the effect of fluctuation etc. of a refractive index was suppressed and the dimensional accuracy of a pattern improved. In addition, to the spherical aberration generated by quartz aperture insertion, it amended beforehand.

[0020] (Example 4) In the projection aligner of an example 2, as shown in drawing 5 , the quartz parallel plates 32 and 33 were formed between optical system and a substrate, and the liquid container was divided into the optical-system side liquid container 34 and the substrate side liquid container 35. Furthermore, it was made to perform the scan or step feed to the optical system of a substrate 5 the whole substrate side liquid container 35. Thereby, since the flow of the liquid near the substrate was also controlled, the effect of fluctuation etc. of a refractive index was suppressed and the dimensional accuracy of a pattern improved further.

[0021] In addition, when applying the configuration by this example to an example 1, the same device also as a mask side can be established.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The explanatory view of the principle of this invention.

[Drawing 2] The explanatory view of the aligner by one example of this invention.

[Drawing 3] The explanatory view of the aligner by the second example of this invention.

[Drawing 4] The explanatory view of the aligner by the third example of this invention.

[Drawing 5] The explanatory view of the aligner by the fourth example of this invention.

[Description of Notations]

2 [-- A reflective mold cutback projection lens 11 / -- Excimer laser, 12 / -- A laser beam, 13 / -- Beam plastic surgery optical system, 14 / -- Liquid container.] -- An illumination-light study

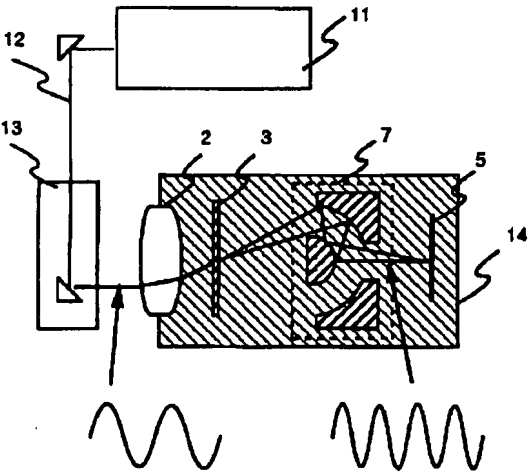
system, 3 -- A mask, 5 -- A substrate, 7

[Translation done.]

DRAWINGS

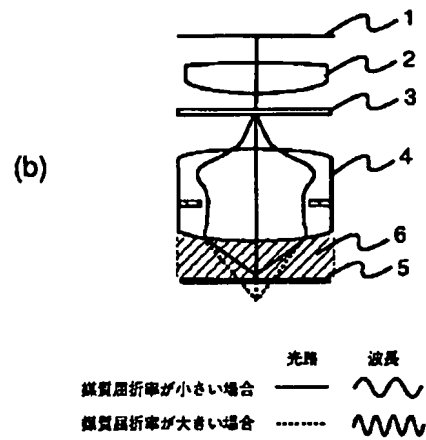
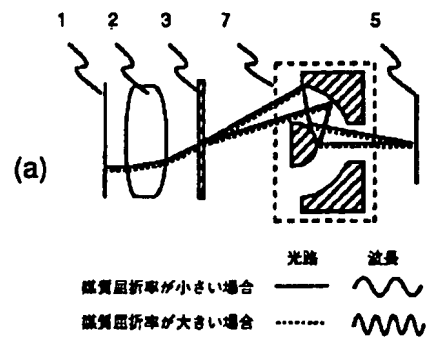
[Drawing 1]

Fig 1



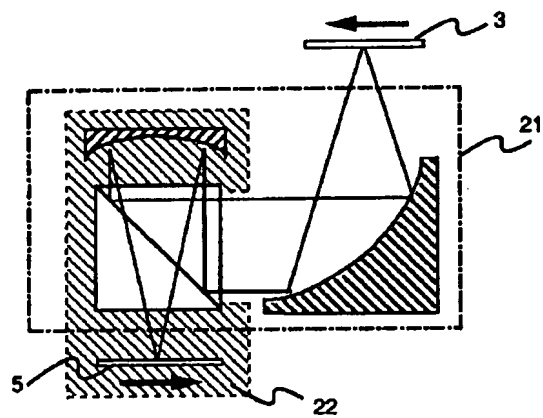
[Drawing 2]

図 2

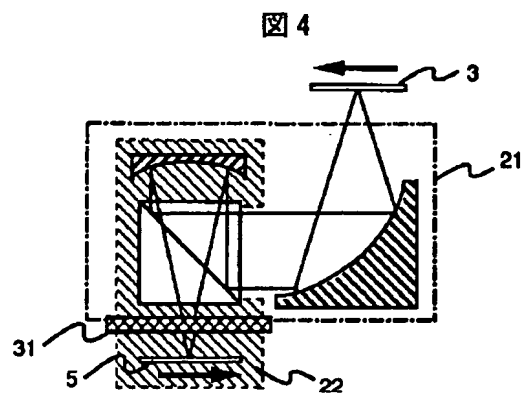


[Drawing 3]

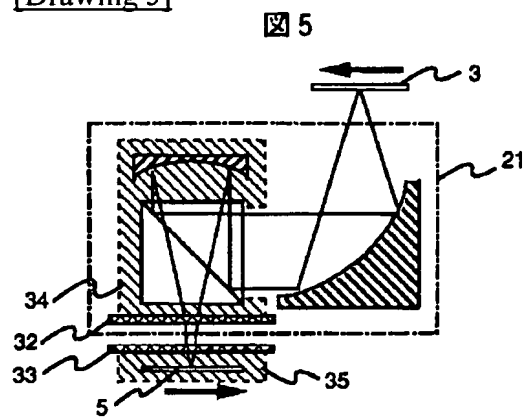
図 3



[Drawing 4]



[Drawing 5]



[Translation done.]